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COMPARISON OF HIGH ACUITY SCORES ON SNELLEN AND ORTHO-RATER TESTS

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SUMMARY PAGE

THE PROBLEM:

To determine the relation between Snellen acuity scores and Ortho-Rater acuity scores for levels of acuity at or above 20/20.

FINDINGS:

A table of equivalents was established for the two types of acuity tests. It was shown that Snellen scores in the higher ranges give a false implication of the degree of retinal resolution associated with these scores.

APPLICATIONS:

The results of this investigation will be useful to optometrists and ophthalmologists in assessing visual acuity for occupations such as Lookout duty.

ADMINISTRATIVE INFORMATION

This investigation was undertaken as a part of Bureau of Medicine and Surgery Research Project NM 23 00 00—Assessment of Personnel for Duty in Undersea Warfare, under Subtask (4) of Task 23 01 20, Psychophysiological Evaluation of Personnel for Submarine Duty and Other Underwater Duty. The present report is No. 1 on this subtask.

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Monograph 225

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COMPARISON OF HIGH ACUITY SCORES ON SNELLEN AND ORTHO-RATER TESTS*

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Visual acuity involves the ability of the eye to discriminate contours as measured by the size of the target item. Since contours can take many forms, it is to be expected that differently shaped contours will yield different values of acuity from the same individual. Evidence of this has been found in many studies, among which the AGO "Studies in Visual Acuity"[1] indicates from the factor analysis that a test may involve as many as four factors: retinal resolution, brightness discrimination, simple form perception, and letter perception. Of these, retinal resolution accounts for most of the variance in test scores and is the primary factor considered in visual acuity measurements. While size is paramount, the indication is that the same item size is not equivalent from one contour to another.

The most widely used acuity test is the Snellen letter chart. This term is loosely applied to any chart of capital letters printed in graded sizes, and several companies offer carefully prepared charts, any one of which is accepted as standard. In principle, the Snellen letter chart is based on a five by five checkerboard square. For example, the E stroke width and the separation of strokes are the same, but when other letters are drawn within a square, the basic premise cannot be maintained. Figure 1. This results in an inequality of the individual test items and subverts the original intent of the letter chart. Nevertheless, clinicians use the charts almost exclusively because most patients are familiar with the task of reading. The factor analysis in the AGO study confirms the high level of retinal resolution in the Snellen test but shows considerable contamination by the letter factor.

In recent years, the checkerboard target has gained in usage through its incorporation in acuity testing devices such as the Bausch and Lomb ortho-rater. Such tests do not depend on literacy and the AGO analysis indicates that the checkerboard target has the highest retinal resolution

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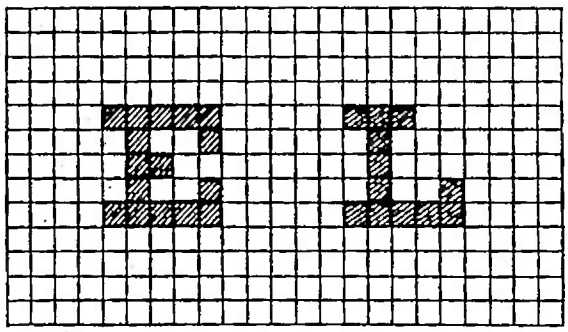

Fig. 1. Block principle of Snellen letters.

factor of any present test, without significant contamination by other factors.

When scores from the Snellen charts and from the ortho-rater have been compared, it has been assumed that identical width of stroke of a letter and size of checker give equal measures of visual acuity. However, since these are radically different contours and have different factors, it should not be expected that their equivalence will be based on equal size. A comparison of the tests was undertaken to determine their size relationship and to set up a transformation equation of acuity score from one test to the other.

METHODS AND PROCEDURE

Test Conditions: The letter test was given in a vision alley painted and illuminated in conformity with the standards set by the Army-Navy NRC Vision Committee.[2] Brightness of the chart averaged 14.0 footlamberts with readings of 15.5 and 12.5 ft.-L from top to bottom, respectively.

Targets: Three American Optical Company Snellen wall charts, No. 1930, were used interchangeably. For variation, while retaining equal difficulty, the letters were cut out, rearranged and reset in their proper lines. The marks of these alterations were not visible at 20 feet. Monocular testing was obtained with the use of a flat opaque occluder.

A commercial Bausch and Lomb ortho-rater was used for checkerboard monocular distance acuity measures.

Scoring: The Snellen score recorded was the smallest line read correctly allowing one error. Ortho-rater score was the last correct report of the checkerboard position followed by two consecutive errors.

Subjects: A total of 1,071 scores in each of the two tests was obtained from men in the submarine service during a visual screening of the personnel of fifteen boats.

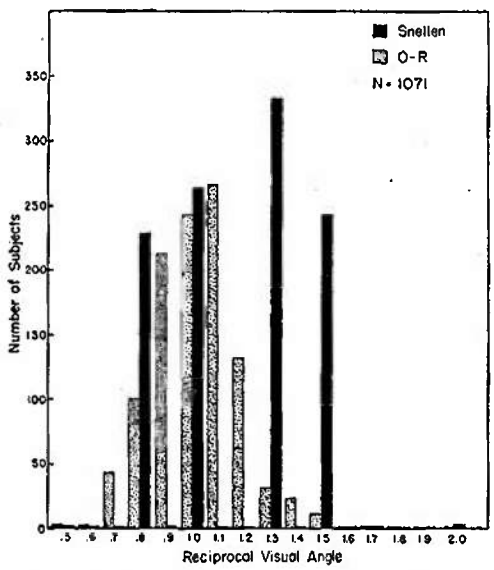

Fig. 2. Frequency distribution of Snellen and ortho-rater high acuity scores from an unselected submarine population.

RESULTS

Two histograms were drawn on the same base line in Figure 2 showing the distribution of Snellen and of ortho-rater scores. The placement of both the Snellen and ortho-rater scores on the abscissa is at the equivalent reciprocal visual angle for stroke of letter and for size of checker. The reciprocal visual angle is used in this and other diagrams because visual resolutions will then plot in a straight line. The obvious difference between the distributions is that while the frequencies in each of the Snellen categories are substantially the same, ortho-rater scores approach a normal distribution. Very few resolution scores of 1.3 to 1.5 were found with the ortho-rater whereas the Snellen test gave a high frequency at 20/15 and 20/13, the so-called equivalents.

Replotting the data in a scattergram, Figure 3, helps to bring the differences into better focus. The plotting is in the same units as the previous diagram, i.e., reciprocal visual angle.

It was suspected that the regression line of y on x was not linear so a test was made by finding *eta* (0.5754), the correlation ratio, and comparing it to *r* (0.5517), the coefficient of correlation. Since *eta* was found to be significantly larger than *r* at the 1% level of significance, the regression line of y on x is a nonlinear function.

DISCUSSION

An examination of Figure 3 shows that the increase in resolution

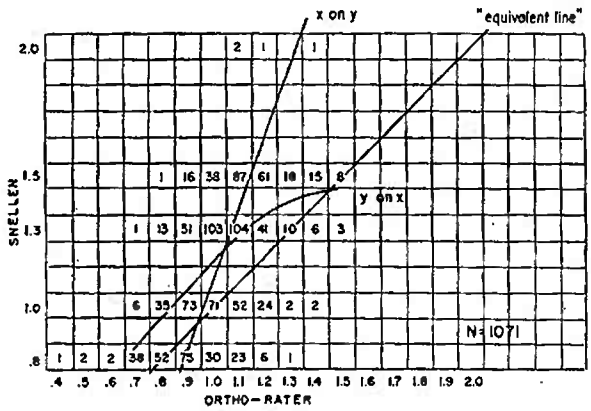

Fig. 3. Scattergram and regression lines of Snellen and ortho-rater high acuity scores.

is not as rapid as the increase in Snellen score would lead one to believe. These differences must be due primarily to the letter factor which results in the high Snellen "acuity" scores without corresponding increase in resolution. This is evident because a score of 20/10 which should indicate twice as good an acuity as 20/20 and therefore a resolution score in the ortho-rater of 20 (2.0 reciprocal visual angle) gives a score of only 12 (1.2 reciprocal visual angle). This means that the subject cannot see "twice as well" in the case of 20/10, but that he has learned to utilize the additional cues. Similarly 20/13 and 20/15 indicate ortho-rater scores of 15 and 13 respectively (1.5 and 1.3 reciprocal visual angle).

Unfortunately, the idea that 20/10 means a man's vision is twice as good as that of a man with 20/20 is carried to other visual tasks, when in reality his retinal resolution, the basic factor in acuity, is only perhaps 20 per cent better.

Table I lists the equivalent score when going from one test to the other. Due to the nonlinearity of the regression line, the average score for the distribution within a category was used as the predictor.

TABLE I

Conversion Scores from One Test to the Other

Ortho-Rater to Snellen		Snellen to Ortho-Rater	
7	20/25	20/25	9
8	20/22	20/20	10
9	20/20	20/15	11
10	20/17	20/13	11
11	20/15		
12	20/15		
13	20/14		
14	20/14		
15	20/13		

It should be remembered that going from test A to test B is not the same as going from B to A. Therefore, an ortho-rater score of 15 predicts a Snellen score of 20/13 but a Snellen score of 20/13 predicts an ortho-rater score of 11. The regression lines in Figure 3 are drawn through the averages of the distribution in each direction and are thus the best predictive scores for each distribution.

SUMMARY

Evidence is presented showing that high Snellen scores are only moderately predictive of high ortho-rater scores and vice versa. This is attributed primarily to the letter factor which gives additional clues to resolution and prevents presumed equality of resolution of letter stroke and checker size. A new conversion for high scores on both tests is presented which is derived from testing a large population having high acuity.

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